"Experimental and Theoretical Study of Ionospheric Electron Content and Upper Ionosphere Ionic Processes by Means of Satellite Radio Transmissions"

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Ionosphere Research Laboratory

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1. Introduction

A number of experimental programs have been conducted during the report period, based on the use of radio beacon transmissions from satellites for the study of the ionosphere. These experiments involve the measurement and interpretation of the refraction, dispersion, and diffraction characteristics of the ionosphere on the beacon transmissions, as they are observed at ground level.

The program is at present in a very active experimental phase using the satellites S-66 (Explorer 22) and BE-C, whose orbits are such that they cross this midlatitude station respectively in the north-south and west-east directions. Some earlier investigations, using data from other satellites, have also been completed or are in the final stages of analysis.

2. Research in Progress

2.1 Satellite Recording Program

The S-66 satellite has been recorded on a regular schedule throughout the report period, with phase and amplitude data being taken on the frequencies 20 Mc/s, 40 Mc/s and 41 Mc/s. Recording of the 360 Mc/s beacon transmission has been temporarily discontinued. Approximately 750 passes have been recorded on magnetic tape at the State College station and about 300 passes at the Huancayo station.

A less extensive program of recording has also been conducted using the BE-C satellite; at the State College station attention has been directed to those passes of the satellite which pass in the direction closely longitudinal to the magnetic field, as well as to occasional selected sequences of consecutive satellite passes, while at the Huancayo station

recordings are made particularly of passes which occur near sunrise.

All recordings at the State College station are now made automatically according to a predetermined schedule with satellite acquisition and tracking being accomplished automatically. The operation of the Huancayo station involves manual acquisition and automatic tracking procedures.

A program for studying the variations of ionospheric electron content through the observation of polarization rotation from a geostationary satellite, Early Bird, were discontinued when the satellite minitrack beacon failed before useful data was acquired.

2.2 S-66 Electron Content Analysis

The conversion of satellite data recorded at the State College station to values of integrated electron content is now in an advanced stage. Following on some initial exploratory studies of reduction techniques, a uniform analysis procedure has now been developed and all S-66 data through July 15, 1965 have been reduced by this method. This comprises a total of approximately 550 passes.

For each satellite pass the electron content has been plotted as a function of ionospheric point latitude since the trajectory of the ionospheric point is approximately along a meridian. The latitudinal distribution of electron content at times shows abrupt changes between two consecutive passes at approximately a two hour interval. On several occasions also the distribution appears to be highly unusual. A number of the more unusual distributions have been checked for consistency using the 20-40 Mc/s Doppler data and have been found to be real.

A preliminary report on S-66 electron content analysis has been

published as a laboratory scientific report.

2.3 Scintillation Studies

Spaced receiver amplitude and phase data continue to be recorded on a regular schedule over a 3000 foot N-S baseline interferometer, operating at the harmonic frequencies of 20 Mc/s and 40 Mc/s. In addition amplitude and phase dispersion scintillation is recorded routinely at the main observing site using the same satellite frequencies. Principal emphasis has been placed on the determination of the separate power spectra of the phase and amplitude scintillation. Theoretical work is underway to relate these measurements to the spatial correlation function of the ionospheric perturbations producing the scintillation.

2.4 Analyses of Past Data

A number of separate studies based on data recorded from the Transit 4A satellite both at the State College and Huancayo station, are now either completed or in an advanced stage. A number of experimental techniques have been developed through these studies and their completion will in many cases be a prelude to the application of these techniques to S-66 and BE-C data.

A study of sunrise conditions in the equatorial ionosphere has been published as a scientific report, presented at the 1965 COSPAR meeting, and will be published in the proceedings of this conference.

A one year study of the undisturbed mid-latitude ionosphere, which was published earlier as a scientific report, has now been extended and has been submitted for publication in the scientific literature.

A study of the diurnal, day to day, and annual variations of the equatorial ionosphere for the period September 1961 through February 1963

has now been completed and is being submitted for publication.

2.5 Other Satellite Studies

An experimental program is being set up for the study of polarization scintillations in satellite radio signals. It is believed that these studies will complement studies of the phase and amplitude scintillations and should lead to improved understanding of the scintillation process.

By means of a simultaneous analysis of Faraday rotation and Doppler shift effects, it is possible to determine the variation of ionospheric height across the field of view of a receiving station. For an equatorial station this approach gives a good measure of relative height changes, while for a mid-latitude station it is possible to determine the height absolutely although with rather lesser resolution.

3. Papers and Publications

"An Investigation of Second-Order Corrections to First-Order Ray Theory as Applied to Beacon Satellite Transmission Studies" by Nevin D. Foltz, I. R. L. Scientific Report No. 225, November 15, 1964.

"Solar Ionizing Flux as Determined from Sunrise Measurements of Electron Content" by A. Gran, I. R. L. Scientific Report No. 240, May 30, 1965.

"Variations in the Total Electron Content of the Ionosphere at Mid-Latitudes During Quiet Sun Conditions" by S. Solomon, I. R. L. Scientific Report No. 256, November 30, 1965.

"The Total Electron Content of the Ionosphere in Middle Latitudes" by F. H. Hibberd and W. J. Ross. Submitted for publication in J. G. R.

"Some Geophysical Measurements Using Extended Range Observations of a Radio Beacon Satellite" by A. A. Gran, J. D. Kolesar and W. J. Ross. Presented at the May 1965 COSPAR meeting, Buenos Aires, Argentina. This paper will also be published in the proceedings of this conference.

4. Personnel

William J. Ross (Ph. D. Auckland University, 1955) Professor of Electrical Engineering.

J. Wayne Porter (M. S. University of Pennsylvania, 1959) Doctoral Candidate in Electrical Engineering.

Murray L. Rafael (M. S. Pennsylvania State University, 1965) NASA Predoctoral Trainee in Electrical Engineering.

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